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THE CASTOR-BEAN PLANT AS A SOURCE OF INSECTICIDES
A REVIEW OF THE LITERATURE

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Interest in the use of the castor-bean plant (Ricinus communis L.) for the control of insects has been stimulated in the past few years by popular articles declaring that crops could be protected by means of border or strip plantings of this plant, and also by the recent development of a new spray material extracted from its leaves.

In order to learn the basis for these reports and to determine whether it would be worth while to do more work on the castor-bean plant as a source of insecticides, a search of the literature was made. The information obtained is briefly reviewed in the following notes.

Insects Reputed to Be Affected

Grasshoppers.--In New South Wales it was suggested that castor-beans be sown in small patches near the breeding ground of grasshoppers for the purpose of destroying this pest. This plant was reported to be fatal to grasshoppers. In fact, it was said that "the locusts will fairly bury up the young plants, so thickly will the dead accumulate underneath them."--Anonymous (2).

In Victoria, Australia, the planting of Ricinus communis on the borders of fields was considered an efficacious means of controlling locusts.--Navas (36, p. 109).

Swarms of immature grasshoppers, Schistocerca gregaria (Forsk.), were observed in Senegal, Africa, damaging various plants, but Ricinus was not attacked.--Trochain (47, p. 556).

The following statements are from a newspaper clipping (June 26, 1938) sent by Roger C. Smith, of Manhattan, Kans. "Castor-bean plant may prove nemesis of hopper. It may be solution to pest problem. Certain varieties are highly toxic to grasshoppers." Such was the opinion of Leo M. Christensen and Harry Miller. In 1937 these men discovered by accident that certain varieties of the castor-bean plant are highly toxic to grasshoppers and other insects. The discovery came about when the two scientists, who are experts in the field of chemurgy, were studying castor-beans as a commercial vegetable and cellulose crop. In 1938 they learned more details concerning the toxic effect of castor-

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bean plants on insects. They had an experimental plot in the Missouri River bottoms, a few miles east of Atchison, Kans.

The following observations were supposedly made by Dr. Christensen: A 15-acre field in Kansas was planted with various plants. The outer barrier consisted of 10 rows of sorghum and then came two-thirds of a row of castor-beans. That short row of beans almost stopped the grasshoppers that migrated from a weedy field next to the sorghum. They chewed at it by day and roosted heavily there at night. They appeared dopey, and then died. So great was their passion for the castor-bean plant that they hardly touched other plants on either side of the barrier. Away from the castor-bean barrier the grain losses from birds and hoppers ran up to 95 percent. Along the barrier the grain loss ranged from 35 percent to none at all. The barrier was of two varieties of castor-bean, cambodgensis being much more effective than the larger variety, zanzibarensis. When 10 castor-bean plants were transplanted to a cornfield swarming with grasshoppers, the hoppers left the corn to eat the transplants completely, and then died. In a park dead hoppers were found beneath ornamental castor-bean plantings. In a test 19 hoppers were caged with some castor-bean foliage, which killed 16 of them in 48 hours.--Bear (10).

The story of Dr. Christensen's 17-acre experimental farm near Atchison, Kans., was again told in 1942. Fifteen acres of this farm were devoted to the growing of weeds and the other 2 acres to grain sorghums, castor-bean plants, and other things not planted by plains farmers.--Borth (11, pp. 176-181).

The evidence available does not indicate that castor-bean plants have any great importance in grasshopper control, but it is insufficient to warrant a statement that no variety of them has any value for that purpose. Certainly, the extravagant claim that they seem certain or even likely to solve our grasshopper-control problem is not justified.--Bare (9).

Growing castor-bean plants to eliminate grasshopper damage to crops does not work, despite some publicity to the contrary. The conclusion that these plants are of no value in grasshopper control came as a result of an experiment conducted over a period of 3 months which involved at least 500 grasshoppers and several varieties of castor-beans.--[Drake] (19).

Tests have proved that castor-bean foliage is not poisonous to grasshoppers or other insects.--Oklahoma Agricultural Experiment Station (38, p. 212).

In order to settle the controversy invoked by Dr. Christensen's observations, carefully planned experiments were conducted in Kansas. Tests with grasshoppers caged over castor-bean plants were first conducted, in both the laboratory and the field. The four varieties used

were zanzibarensis, variegatus, cambodgensis, and a community selection called "Wagner." The cage tests indicated that grasshoppers live fairly well--some as long as 66 days--on an exclusive diet of castor-bean foliage and petioles. Observations on feeding showed that grasshoppers did not relish any part of the castor-bean plants. Some individuals refused to eat the foliage and grew weaker from lack of food, while others, either from weakness or mild poisoning, appeared to be partly paralyzed, in which condition they often survived as long as 3 days. The supposition that castor-beans have an attractive value may have arisen from seeing grasshoppers and other insects alight on these plants, which grow tall, almost treelike, and offer perches, shade, and a certain amount of protection from enemies. Food attractiveness is not necessarily involved when insects perch on the stems or leaves. It was concluded that "castor-beans cannot be used as a trap crop because they are not more attractive to grasshoppers and other common pests than the usual crop food plant. While castor-beans are apparently objectionable to grasshoppers, crops cannot be adequately protected by border or strip plantings because of the easy mobility of the hoppers. No evidence of any value of castor-beans for poisoning, repelling, or trapping grasshoppers or any other crop insect pest was observed during the season of 1938. No real protection was observed in farm plantings and none was reported by farmers." A long list of insects found on castor-bean plants in Kansas was also published.--Smith (44).

The erroneous idea has been widely held that grasshoppers may be poisoned by planting castor-beans around and through the crops to be protected. Experiments conducted by the United States Bureau of Entomology and Plant Quarantine and several State experiment stations indicate that this practice has no value. When given no food other than castor-bean foliage, grasshoppers will eat sparingly of it and will die in about the same time as when given no food. When they are given a choice, other plants are preferred. Young grasshoppers have been reared to the winged stage in cages containing growing castor-bean and oat plants. They thrived on the oats, but did no more than nibble on the castor-beans although they grew to maturity on them.--Parker (39).

According to a compilation on the "Insects of the Castor-Bean," this plant has attracted attention as an alleged killing agent for insects, particularly grasshoppers and the Japanese beetle, but the literature contains only a few records of insects being poisoned by feeding on the plant.--Myers (35).

Tests in Iowa gave no evidence that grasshoppers are attracted to castor-bean plants. Common crop plants were selected in preference to the eight varieties of Ricinus tested in cages. Neither was there any evidence of a repellent effect, because the grasshoppers used in these tests often rested on the plants, and under field conditions grasshoppers have been observed to spend the night resting on castor-bean plants and then to move in the morning to other plants to

feed. Since grasshoppers were able to survive longer on an exclusive diet of castor-bean plants than without food, the poisonous principle in the plants had very little, if any, effect on the insects. Therefore, these plants could not be regarded as having any direct value in the control of grasshoppers or in preventing them from injuring crops.--Spain (45).

It was thought that the conflicting reports on the toxicity of castor-bean foliage to grasshoppers might be due to differences exhibited by different varieties of the plant. The following 11 varieties of Ricinus communis were tested on nymphs and adults of Melanoplus differentialis (Thos.): africanus, bourboniensis, Brazilian, cambodgensis, communis, Duchess of Edinburgh, gibsoni, panormitanus, Red Spire, sanguineus, and zanzibarensis. Individual nymphs were caged on the leaves and the amount eaten was noted daily. With zanzibarensis 8 days and with Red Spire 37 days were required to obtain 50 percent kill. The other varieties showed intermediate periods. Some of the nymphs that survived transformed to adults on the foliage. The amount of foliage eaten by the nymphs and adults that died was barely sufficient to sustain life, so that the factor of starvation could not be eliminated. There can be no doubt that castor-bean foliage contains a toxin, for a number of nymphs that fed on the foliage were paralyzed in the legs, although some so affected continued to live for days. The foliage of no variety tested, however, was found to be sufficiently toxic to be satisfactory as a practical insecticide.--Hartzell and Wilcoxon (26, p. 138).

Beetles.--Twenty-four acres of tea bushes were interplanted with castor-bean plants to test the value of the latter as trap plants to help control the tea shot-hole borer (Xyleborus fornicatus Eichh.) in Ceylon. This method of controlling these beetles was apparently effective, provided the infested castor-bean branches were systematically removed.--Jepson (30).

Castor-bean plants grown near sugarcane in Puerto Rico will attract many weevils.--Wolcott (52).

Pests of the avocado in Puerto Rico include the weevil Diaprepes abbreviatus (L.), which attacks the leaves and is only repelled by arsenical sprays, but may be attracted by a trap crop of castor-bean plants.--González Ríos and Mayoral Reinat (22).

In northern Caucasus larvae of Pedinus femoralis (L.) that were fed on seedlings of castor-beans survived.--[Stepantzev] (46).

Castor-bean plants grown near sugar beets in Rumania were attacked by (Cleonus) Bothynoderes punctiventris (Germ.). All the beetles feeding upon the cotyledenous leaves died, 10 to 15 being found dead daily around each plant.--Grinberg (24).

A large seed establishment at Bristol, Pa., announced a new and natural control for the Japanese beetle. When castor-beans were planted a short distance from the flowers, the beetles left the flowers and swarmed over to the castor-beans, eating the large leaves. These plants caused slow but sure death, and great piles of beetles were swept up from under them each morning. Ten cents worth of castor-bean seed planted a short distance from a garden was considered to help solve the Japanese beetle problem.--Landreth (31, 32).

Owing to the publicity given to this discovery, a series of tests was conducted by the Bureau of Entomology and Plant Quarantine at its Japanese beetle laboratory in 1932 to determine the attractiveness and toxicity of the castor-bean plant to the Japanese beetle. Tests were made on 6 varieties of this plant--cambodgensis, panormitanus, gibsoni, Red Spire, sanguineus, and zanzibarensis--grown at Moorestown, N. J. The beetles fed on the foliage of sanguineus and zanzibarensis, but the other varieties were practically immune. Large numbers of dead beetles were found under these plants, but they could also be found under other plants heavily infested by this insect. Under certain field conditions, however, castor-bean foliage appeared to be toxic to the beetles. In cage tests they fed on the foliage to a limited extent. However, no tested variety of castor-bean was sufficiently attractive to induce the beetles to leave favorite food plants nearby. It was concluded that the castor-bean plant was of little or no value as a trap plant for the beetles under usual field conditions.--Metzger (34).

Japanese beetles do not feed on all varieties of castor-beans, and the toxic property of varieties fed on is not at all uniform. Certain varieties do have some killing power, but it is not nearly so great as has been alleged by those advocating the use of this plant to destroy the insect.--Hawley and Metzger (27).

An extension horticulturist received a letter from a gardener in northern New Jersey requesting an immediate visit to see what he had discovered concerning beetles on his lima beans. About 100 feet from the beans the gardener had planted a row of castor-beans; on inspection, he found the ground beneath the castor-beans covered with hundreds of dead beetles, probably Asiatic garden beetles (Autoserica castanea (Arrow)). The leaves showed evidence of feeding by the beetles.--Nissley (37).

In some parts of Manchuria the castor-bean plant was cultivated with other plants to prevent injury to the latter by insects. Adult beetles (Autoserica orientalis (Motsch.)) that had fed on these leaves for 24 minutes in the laboratory became paralyzed in 56 minutes and died after 157 hours; outdoors, 94 percent died in 4 days. Recovery from the paralysis was 6 percent outdoors and 35 percent in the laboratory.--Tsuchiyama (48).

Ants.--To protect plants from ants the natives of Brazil grow castor-bean plants in their gardens. If the seeds are placed on the glowing fuel in the combustion chamber of an ant-fumigating apparatus, the fumes form a deposit in the nest which not only kills the ants but prevents reinfestation.--Gobbato (21, p. 304).

Flies.--A cafe proprietor who had placed a castor-bean plant in his dining-room was surprised to find all the flies in the room dead beneath the plant. This statement has been questioned, however, by people who have found no trace of dead flies near or beneath this plant.--Carrière and André (15, 16).

This plant was stated to be efficacious in freeing rooms of insect life, the leaves containing a substance fatal to flies and other insects.--Anonymous (1).

Mosquitoes.--The Indian Medical Record for March 16 [1893] is quoted as follows: According to a Bombay newspaper the castor-bean plant gives protection against mosquitoes. In Egypt it is planted about the houses to drive the insects away. In towns, a better plan is to have the growing plants in pots and to bring them into the house for a day or two at a time. It was reported that the mosquitoes were killed by a poison found on the under side of the leaves, and if a dozen leaves were placed about a room swarming with mosquitoes, the insects would disappear without leaving any dead lying about.--Anonymous (3).

Castor-bean plants helped to drive mosquitoes away.--Von Mueller (50, p. 487).

Castor-beans planted near a house in New Jersey had no repellent effect on mosquitoes.--Smith (43, p. 543).

During the winter of 1901 a great deal was reported in the newspapers about the cultivation of this plant to keep mosquitoes away. These notes were based mainly upon the report of a consul from Venezuela, who had castor-bean plants growing profusely around his residence. Seeds from these particular plants were brought to the United States and planted on the grounds of the Department of Agriculture in Washington, D. C., and also in New Jersey, but observations indicated that mosquitoes were not at all deterred by the plants. In 1903 another consul reported a similar belief among the natives of Yucatan, and he also confirmed this belief to a certain extent experimentally. An Indian journal reported that six potted castor-bean plants that had been placed in a room were thickly covered by mosquitoes, which seemed "to be actually invigorated by the apparently stimulating effect of their new quarters." In experiments in Algeria castor-bean plants were found to be without effect as deterrents against mosquitoes.--Howard (29, pp. 23-25).

Parts of Castor-Bean Plants Tested as Insecticides

Decoction and juice of plant.--A decoction of the leaves was used to destroy aphids and other insects.--Carrière and Andre´ (16).

Juice from the leaves and green pods had only a slight effect on honeybees.--McIndoo and Sievers (33, p. 9).

The sap killed beetles (Cleonus) Bothynoderes punctiventris (Germ.) in Rumania.-- Grinberg (24).

When newly hatched grasshoppers were confined in screened cages over young, succulent plants, half of them were dead at the end of 48 hours, one-fourth more in 72 hours, and the remainder in 96 hours. Only slight feeding was done on the plants.--Smith (44, p. 756).

Extracts of seeds and leaves.--An alcoholic extract of castor-bean seeds, when reasonably strong and used with soap, was inefficient against three species of aphids, and when fed to silkworms without soap it had no effect on them. A benzene extract of the seeds, when exceedingly strong and used with soap, was efficient against one of these aphids, but the control mixture killed half as many.--McIndoo and Sievers (33, p. 9).

Water and acetone extracts of the seeds and leaves killed less than 50 percent of the mosquito larvae tested and were not toxic to grasshoppers.--Hartzell and Wilcoxon (26, p. 136).

Ricin, a toxic protein, and ricinine, an alkaloid, are known to occur in the seeds as well as other parts of the castor-bean plant. While it is known that both these compounds are poisonous to vertebrates, little is known of their effect on insects. In tests by Fales a 1-percent solution of ricin in water caused no mortality of flies, and a 1-percent solution of ricinine in acetone caused only 1-percent mortality.--Haller and McIndoo (25).

Grasshoppers fed for 7 days on wheat plants dusted with ricin were not appreciably affected, although their bodies became covered with the white powder. Preparations of ricin and ricinine, incorporated in bran-mash baits and fed to grasshoppers, also showed no toxicity whatever. The utility of the castor-bean plant as an insecticide awaits the proper chemical methods of extracting the specific toxin for insects.--Hartzell and Wilcoxon (26, p. 138).

Ricin and ricinine were tested against codling moth larvae by the apple-plug method. These materials were used at the rate of 4 pounds per 100 gallons of water or water containing 20 percent of alcohol. Following the application of ricin 98 percent of 101 plugs, and of ricinine 1 percent of 98 plugs, were wormy and none were stung. Of 95 plugs treated with lead arsenate at the same

rate, 18 percent were wormy and 16 percent stung, and of 93 check plugs (water plus alcohol) 95 percent were wormy and none stung.--Siegler and coworkers (42).

A mixture containing ricin, the toxic ingredient in castor-bean, was the least effective material used against the European red mite in 1942.--Bourne and Whitcomb (13).

Unsatisfactory materials tried in 1942 against the common red spider on greenhouse plants included a preparation containing castor-bean extract (ricin).--Whitcomb and coworkers (51).

A spray containing castor-bean extractives in 1943 was ineffective against the onion thrips, chiefly because of its oily nature and poor wetting qualities.--Bourne (12).

Powdered or crushed seeds.--The powdered beans or husks, free from oil, killed all the honeybees tested; but some of this powder, extracted with a 10-percent solution of sodium chloride, apparently did not kill any of the bees. The powder had no effect on webworms, but had a slight effect on silkworms, flies, and grasshoppers.--McIndoo and Sievers (33, p. 9).

Crushed castor-bean seeds incorporated in bran-mash baits were not toxic to grasshoppers.--Hartzell and Wilcoxon (26, p. 138).

The ground cake of the castor-bean had no effect on fly larvae in manure.--Cook and Hutchison (18, p. 4).

Castor-bean cake has been used as an insecticide in India.--Roark (41, p. 34).

Castor oil.--[No attempt has been made in this review to include references to derivatives of castor oil useful as insecticides or adjuncts.] Castor oil, either alone or mixed with sugar, attracted houseflies and was an active poison for them. Since other oils, e. g., olive or nut oil, had no such toxic action, the action of castor oil was not merely mechanical. Adding 2 drops of croton oil to 1 ounce of castor oil greatly increased the toxic action on flies.--Boyé and Guyot (14).

The following poisonous bait was recommended for houseflies in dwellings in France: Castor oil 30 gm., croton oil 2 drops, mixed with sugar or molasses. The effect was stated to be instantaneous.--Chavigny (17, p. 310).

During the fly plague in Germany in 1930 castor oil was used as one measure of control. It had a very toxic effect upon adult flies, and was readily taken by them if it was mixed with sugar or molasses.--[Germany]-Reichsgesundheitsamt (20, p. 30).

Attempts to Develop a Commercial Insecticide from the Castor-Bean Plant

An insecticide derived from the leaves of the castor-bean plant was reported which could be produced commercially both for household-pest extermination and for agricultural uses.--Reimold (40).

In an editorial discussing the various uses of castor-beans, it was said that the powdered leaves produce an insecticide which has been extensively tried, especially in citrus groves, and found effective in repelling aphids, mosquitoes, whiteflies, and rust mites.--Anonymous (4).

A new proprietary spray containing an extract from leaves of the castor-bean plant was claimed to have been highly effective against all kinds of insect pests, operating both as a contact and as a stomach poison, and was stated to have been used in large-scale experiments, principally in Florida, for the protection of garden truck and citrus fruits.--[Holzcker] (28).

Florida entomologists tested a liquid castor-plant product which was placed on the market in 1940 and early in 1941, but it was unsatisfactory for control of five species of insects.--Anonymous (6).

It was reported in 1942 that a commercial company was producing insecticidal toxins derived from the castor-bean plant. All the toxins in the plant had not been isolated, but the products were described as satisfactory for the control of scale insects and several species of spiders in Florida citrus groves and in New England apple orchards. Castor-bean extracts were said to be suitable for agricultural insecticides, but not for household use.--Anonymous (5). See also Anonymous (7).

An insecticide from the extractives of the leaves and other parts of the castor-bean plant, called Spra-Kast, at first was made in liquid form, and when diluted 1 part to 50 parts of water served well in the citrus groves of Florida. The dry Spra-Kast, developed later, was even more potent and more successful; 4 pounds of it were used in 100 gallons of water. Insects reported as controlled by Spra-Kast include many infesting beans, beets, cabbage, cucumbers, potatoes, spinach, tomatoes, melons, lettuce, and peas.--[Good] (23).

A patent pertains to an insecticide, containing extracts of the leaves and stalks of the castor-bean plant, which is effective against dog and cat fleas, the sticktight flea, chicken lice, and mites.--Van Over (49).

A commercial insecticide made from the castor-bean plant was reported to have excellent wetting and spreading qualities and to be

promising against certain aphids and the onion thrips. It acted slowly against the Mexican bean beetle and was considerably repellent so that there was little feeding.--Anonymous (8).

An insecticidal principle possibly is present in the castor-bean plant only under certain conditions with respect to variety, cultural practice, and environment. It would appear that the accepted use of the castor-bean plant as a source of insecticide awaits the isolation, identification, and methods of analysis of the specific substances toxic to insects.--Haller and McIndoo (25).

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